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SCHEDULING OPTIMIZATION OF KRI ASSIGNMENTS WITH BINARY INTEGER PROGRAMMING TO SECURE THE KOARMATIM SEA AREA

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ABSTRACT

Scheduling is an assignment activity related to a number of constraints, a number of events that can occur in a period of time and place or location so that the objective function as closely as possible can be fulfilled. In the hierarchy of decision making, scheduling is the last step before the start of an operation. Scheduling the assignment of KRI in Koarmatim is an interesting topic to be discussed and resolved using a mathematical method. The scheduling process of KRI assignments at Koarmatim is done to produce annual JOP / JOG. This process requires not only rapid follow-up, but also requires systematic steps. The scheduling of assignments applied by Koarmatim is currently carried out by personnel by not using mathematical calculations. The ship assignment scheduling process in this research was carried out using the Binary Integer Programming (BIP) method approach with the aim of minimizing costs and maximizing the purpose of the ship assignment. The scheduling observed was 25 ships carrying out operations for 52 weeks (1 year). The mathematical formulation of the BIP model is made up of one objective function and Three constraint functions. Then the development of the BIP model is then completed, the computer uses Excel Solver. The results obtained that the BIP model applied to scheduling KRI Koarmatim assignments is the maximum coverage area reached is 93,651,234 NM^2, with an area safeguard level of 76,11 from the entire area of operating sector I to IX (1,230,442 NM^2). BIP is an appropriate method to be used as a method in scheduling the assignment of KRI in Koarmatim.

Keywords: *Scheduling, Ship assignments, Binary Integer Programming.*

1. INTRODUCTION.

Indonesia as an archipelagic country has potential problems that become a threat in the national territorial waters (Putra, et al., 2017). At this time Koarmatim coordinated and drafted plans and operations programs for the Republic of Indonesia warship (KRI) in the context of State Defense and Marine Security, especially those operating in the regional sector. In accordance with the Navy's current posture and its ability needs, to deal with various forms of actual and potential threats and be able to provide high deterrent effects carried out through the scheduling of the strength of the Navy fleet, the TNI AL posture is structured on the basis of several components in the integrated fleet weapon system, consists of: Warship, Airplanes, Naval Base and Marine Corps (Yogi, et al., 2017) The combat strength of the batter is urgently needed. Striking force, patrolling force, and supporting force. So that the KRI will be moved according to the needs that will be carried out, both for the amount and class of the ship.

In scheduling carried out by the planners still use the calculation in a manual way and have not done calculations carefully so that in the implementation often JOPs / JOGs that have been made have not been carried out properly.

The purpose of this research is to schedule KRI assignments so that the JOP / JOG that has been made can be a reference in the framework of KRI's operational readiness can always be ready and the operations carried out can be carried out well, especially enforcing the law at sea in the context of maritime security operations.

Several scheduling studies have been carried out both with exact mathematical calculations and metaheuristic genetic algorithms. So that researchers feel very necessary for scheduling in order to optimize the presence of KRI in the sea in the framework of maritime security operations using Binary Integer Programming.

To support this research, researchers have some literature, using Integer Programming find alternative solutions through the data of the shipping companies studied (Andersson, et al., 2011), uses Binary Integer Programming for Robot Path Planning (Ellips & Golnaz, 2015),uses hyper-heuristic algorithm for scheduling problem (Koulinas, et al., 2014), uses Genetic Algorithm for Schedulling Problem (Debels & Vanhoucke, 2007), uses Integer Programming, Simplex, Transportasion Method and then comparative all method (Ayasola, et al., 2015),uses Binary Integer Programming with Genetic Algorithms (Reza, 2017), uses method for project schedulling problem (Das P. & Acharyya, 2013), uses Binary Integer Programming for Power System (Ahmed, et al., 2015) uses Mixed Integer Programming to display ship routing and scheduling and related problems during the new millennium (Christiansen, et al., 2013), uses genetic algorithms for model development in scheduling ship maintenance at the Royal Malaysian Navy (Deris, et al., 1999),uses variable neighbourhood search to Solving Schedulling Problem (Fleszar & Hindi, 2004) Development of container ship maintenance research during sailing (Go, et al., 2013), scheduling for ship routes (Khaled, et al., 2012).

This research is expected to contribute to the science of military operations research, especially in scheduling in the concept of developing strength and ability.

This paper is organized as follows. Section 2 explains the basic concepts of scheduling assignments from Indonesian warships. Section 3 provides paper results. Section 4 describes the making of the schedule from KRI. Section 5 presents the conclusions of the paper.

2. MATERIAL/ METHODOLOGY.

Fig.1 Map of the Armatim Region
(Source: Koarmatim Operations Staff, 2018)

Indonesia is the largest archipelagic country in the world where it has a coastline of around 81,000 km (Astor, et al., 2014), where Indonesia has more than 17,000 islands (Akhira, et al., 94-101) In this case the KRI has the task of securing the sea, where Indonesia has an area covering 5.8 million km² or around 80% of the total area of Indonesia (Hozairi, et al., 2012)

According to the Battleship (Priowirjanto, 2003) is a ship used for military or armed forces. Generally, it is divided into aircraft carriers, combatant ships, patrol boats, transport vessels, submarines and supporting vessels used by the navy such as tankers and tender ships.

Program Integer

Linear programs are one of the mathematical models used to solve optimization problems, namely maximizing or minimizing objective functions that depend on a number of input variables (Bambang & Putri, 2007). While the Integer Program is an approach used in solving linear program problems but requires additional restrictions, namely some or all decisions are integers (Aminudin, 2005).

All Integer Program problems have four general characteristics, namely, as follows (Susanta, 1994):

1) Objective function

Integer Program Issues aim to maximize or minimize in general in the form of profits or costs as optimal results.

Minimize.

$$\sum_{i=1}^{n} A_i + \sum_{i=1}^{n} B_i + \cdots \quad (2.7)$$

2) There are constraints or constraints that limit the extent to which the target can be achieved. Therefore, to maximize or minimize a quantity of objective functions depends on limited resources.

Subject to

$$\sum_{j \in Kix} A_j + B_j + \cdots \geq 1 \;\; \forall\, i \in n \quad (2.8)$$

$$Ai, Bi, \ldots \in \{0.1\} \;\; \forall i \in I \quad (2.9)$$

$$\sum_{i=1}^{n} x_i \leq m_x \quad (2.10)$$

$$\sum_{i=1}^{n} A_i + B_i + \cdots \leq 1 \quad (2.11)$$

3) From the above formulation it can be seen that the goal (2.7) is to minimize the use of the number of ships / facility placement. The delimiter (2.8) shows that each vulnerable point can be reached by a minimum of 1 ship. The delimiter (2.9) shows that the decision variable is a member of binary numbers. Limits (2.10) indicate that each type of vessel may not exceed the number of vessels available. The delimiter (2.11) shows that each of the vulnerable points is not occupied by more than one ship.

4) Decision Variabel

Decision Variables are variables that describe in full the decisions that will be made, which are symbolized by. $X_{1,} X_{2,} X_{3,} \ldots, X_n$.

$$x_i \begin{cases} 1 \\ 0 \end{cases}$$

5) Objectives and limitations in the problem.

Integer programs must be expressed in relation to inequalities or linear equations.

From the illustration above, it can be concluded that the notion of Binary Integer Programming is an optimization problem by doing the following things :

a) Maximizing and / or minimizing a linear function of decision variables called the goal function Z.

b) Price / quantity of decision variables (X_j) must meet a limiting set, each boundary must be a linear equation or linear inequality

c) Sign boundary associated with each variable. For each variable X_j must be non negative ($X_j \geq 0$) or X_j unlimited in marks.

Table 1. KRI Assignment Table

KRI	KOARMADA II					KOARMADA III			
	LANT V	LANT VI	LANT VII	LANT VIII	LANT XIII	LANT IX	LANT X	LANT XI	LANT XIV
	j-1	.	.	.	.	.	.	.	j-n
i-1	X 1,1	X 1,2	X 1,3	X 1,4	X 1,5	X 1,6	X 1,7	X 1,8	X 1,n
.	X 2,1	X 2,2	X 2,3	X 2,4	X 2,5	X 2,6	X 2,7	X 2,8	X 2,n
.	X 3,1	X 3,2	X 3,3	X 3,4	X 3,5	X 3,6	X 3,7	X 3,8	X 3,n
.	X 4,1	X 4,2	X 4,3	X 4,4	X 4,5	X 4,6	X 4,7	X 4,8	X 4,n
i-n	X n,1	X n,2	X n,3	X n,4	X n,5	X n,6	X n,7	X n,8	X n,n

Maximizing KRI coverage areas in the Koarmatim operations sector

Xij = Ship to i (1-50) who will be assigned to Lantamal j (1-9)

Xij = 0, ship to i not assigned at Lantamal to j

Xij = 1, ship to i assigned at Lantamal to j

Conceptual frame work

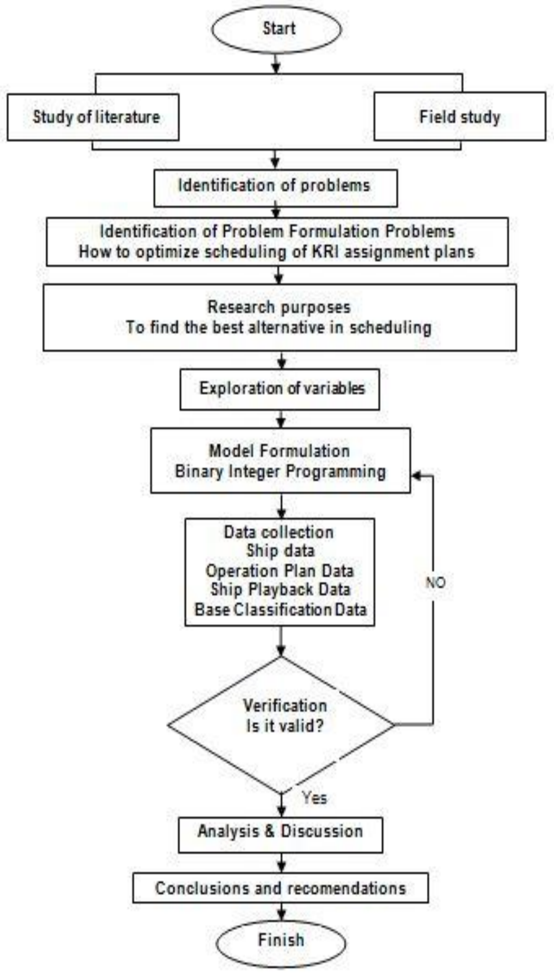

Fig. 2 Conceptual Framework of Research

3. RESULTS AND DISCUSSION.

Table 2. Matrix Of Kri Assignment Table

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	X1,1	X1,2	X1,3	X1,4	X1,5	X1,6	X1,7	X1,8	X1,9
2	X2,1	X2,2	X2,3	X2,4	X2,5	X2,6	X2,7	X2,8	X2,9
3	X3,1	X3,2	X3,3	X3,4	X3,5	X3,6	X3,7	X3,8	X3,9
4	X4,1	X4,2	X4,3	X4,4	X4,5	X4,6	X4,7	X4,8	X4,9
5	X5,1	X5,2	X5,3	X5,4	X5,5	X5,6	X5,7	X5,8	X5,9
6	X6,1	X6,2	X6,3	X6,4	X6,5	X6,6	X6,7	X6,8	X6,9
7	X7,1	X7,2	X7,3	X7,4	X7,5	X7,6	X7,7	X7,8	X7,9
8	X8,1	X8,2	X8,3	X8,4	X8,5	X8,6	X8,7	X8,8	X8,9
9	X9,1	X9,2	X9,3	X9,4	X9,5	X9,6	X9,7	X9,8	X9,9
10	X10,1	X10,2	X10,3	X10,4	X10,5	X10,6	X10,7	X10,8	X10,9
11	X11,1	X11,2	X11,3	X11,4	X11,5	X11,6	X11,7	X11,8	X11,9
12	X12,1	X12,2	X12,3	X12,4	X12,5	X12,6	X12,7	X12,8	X12,9
13	X13,1	X13,2	X13,3	X13,4	X13,5	X13,6	X13,7	X13,8	X13,9
14	X14,1	X14,2	X14,3	X14,4	X14,5	X14,6	X14,7	X14,8	X14,9
15	X15,1	X15,2	X15,3	X15,4	X15,5	X15,6	X15,7	X15,8	X15,9
16	X16,1	X16,2	X16,3	X16,4	X16,5	X16,6	X16,7	X16,8	X16,9
17	X17,1	X17,2	X17,3	X17,4	X17,5	X17,6	X17,7	X17,8	X17,9
18	X18,1	X18,2	X18,3	X18,4	X18,5	X18,6	X18,7	X18,8	X18,9
19	X19,1	X19,2	X19,3	X19,4	X19,5	X19,6	X19,7	X19,8	X19,9
20	X20,1	X20,2	X20,3	X20,4	X20,5	X20,6	X20,7	X20,8	X20,9
21	X21,1	X21,2	X21,3	X21,4	X21,5	X21,6	X21,7	X21,8	X21,9
22	X22,1	X22,2	X22,3	X22,4	X22,5	X22,6	X22,7	X22,8	X22,9
23	X23,1	X23,2	X23,3	X23,4	X23,5	X23,6	X23,7	X23,8	X23,9
24	X24,1	X24,2	X24,3	X24,4	X24,5	X24,6	X24,7	X24,8	X24,9
25	X25,1	X25,2	X25,3	X25,4	X25,5	X25,6	X25,7	X25,8	X25,9

a. Decision Variabel

KRI to 1-25 assigned to operation sector 1-9 -> **(Xi,j)**

Table worth 1, meaning that KRI assigned to the sector

Table worth 0, meaning that KRI not assigned to the sector

b. Objective Function

Maximizing KRI coverage areas in the Koarmatim operations sector

$$\text{Zmax} = \sum_{i\in I}^{n}\sum_{j\in J}^{n} C_{i,j}\ X_{i,j}$$

Cij =Coverage Area KRI i at operastion sector j

Xij = Assigned of KRI at operation sector j

c. Constrain

1) The number of KRI assigned is at least equal to the needs in the sector

$$\sum_{i}^{n} X_{i,j} >= N_{i,j}$$

Xi,j = assignment of KRI i in the operation sector j

Ni,j = KRI needs in the operation sector

2) KRI docking according to the schedule

3) Assignment costs do not exceed budget allocations.

Based on the basis of making the existing steps, the results obtained in solving the problems that will be achieved so as to get optimal results. The first step in Binary Integer Programming (BIP) is that we specify the decision variable.

DECISION VARIABLE

Out of the total of 25 KRI carrying out assignments in maritime security, out of the operating sectors located in Koarmatim there where several ships that carried out maintenance and also carried out docking. So based on the the table, KRI's assignments were as follows:

Table 3. Operating Sector Matrix From Kri

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	0	1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	1	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1	0
6	0	1	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0
8	0	0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0	0	0
10	0	0	0	0	1	0	0	0	0
11	0	0	0	1	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	1	0	0
14	0	0	1	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	1
16	0	0	0	0	0	0	0	0	0
17	0	0	0	1	0	0	0	0	0
18	0	0	1	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	1
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	1	0	0	0	0
22	0	0	0	0	0	1	0	0	0
23	0	0	0	1	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	1	0	0	0	0	0	0	0	0

The table above explains the binary matrix decision variable (BMDV) where 1 states is assigned while 0 is not assigned. Then based on data from the ship operating needs data, the next step will be obtained.

Table 4. Data Needed In Marine Security Operation

No	NAMA / JENIS KRI	KODE	KELAS	KECEPATAN V (KNOT)	ENDURANCE T (JAM)	RADAR/SONAR L (Nm)
1	KRI Untung Suropati	USP	PARCHIM	14	96	50
2	KRI Nuku	NUK	PARCHIM	15	96	50
3	KRI Lambung Mangkurat	LAM	PARCHIM	13	96	50
4	KRI Hasan Basri	HBS	PARCHIM	12	96	50
5	KRI Mandau	MDU	PSK	15	96	50
6	KRI Rencong	RCG	PSK	16	96	50
7	KRI Badik	BDK	PSK	15	96	50
8	KRI Keris	KRS	PSK	16	96	50
9	KRI Pandrong	PDG	FPB	15	120	48
10	KRI Sura	SRA	FPB	16	120	48
11	KRI Hiu	HIU	FPB	15	120	48
12	KRI Layang	LYG	FPB	17	120	48
13	KRI Kakap	KKP	FPB	17	120	48
14	KRI Kerapu	KRP	FPB	15	120	48
15	KRI Tongkol	TKL	FPB	16	120	48
16	KRI Sempari	SPR	PC	15	72	45
17	KRI Tombak	TOK	PC	24	72	45
18	KRI Terapang	TRP	PC	25	72	45
19	KRI Badau	BDU	PC	26	72	45
20	KRI Pari	PRI	PC	23	72	45
21	KRI Sidat	SDT	PC	25	72	45
22	KRI Tedung Naga	TDN	PC	23	72	45
23	KRI Patola	PTL	PC	25	72	45
24	KRI Taliwangsa	TWS	PC	24	72	45
25	KRI Welang	WLG	PC	25	72	45

Based on the above table there are 25 KRIs who are in the ranks of Koarmatim who are ready to be needed in the sea security operation.

Table 5. KRI needs of SECTOR

No	SECTOR	Large (Nm2) A	Average KRI Coverage (Nm2)	Minimum needs of KRI n = A / Coverage
1	SECTOR V	136,000	72,065	2
2	SEKTOR VI	145,250	72,065	2
3	SECTOR VII	152,310	72,065	2
4	SECTOR VIII	125,610	72,065	2
5	SECTOR IX	147,750	72,065	2
6	SECTOR X	132,550	72,065	2
7	SECTOR XI	137,650	72,065	2
8	SECTOR XIII	125,150	72,065	2
9	SECTOR XIV	128,172	72,065	2

Based on the table of KRI needs above, there are 18 ships carrying out sea security operations which are divided into 9 sectors. While 6 other vessels carry out maintenance and docking. Where in docking implementation can be seen from the following table:

Table 6. Schedulling KRI Docking

Fasharkan	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0
6	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1
9	0	0	0	0	0	0	0	0	0

Where:

0 = means KRI is docking

1 = means KRI is ready to be assigned

Based on the docking scheduling table above, KRI is on the order of 1,5,9,13,17,21 and KRI 25 carries out maintenance. So out of a total of 25 KRI, there are 18 KRI assigned to the operating sector, and 7 KRI carrying out maintenance/ docking. After that, the next step will be used.

OBJECTIVE FUNCTION

Table 7. Total Objective Function For Operation

		Coverage Area Achievements (nM2)	Cost Index Rp./Nm2	Operation Cost Achievements	Condition	Total Cost TW I Ops. (Rp.)
KRI 1	Z=	933,694	12,753	11,907,000,000	<=	11,907,000,000
KRI 2	Z=					
KRI 3	Z=	868,894	13,751	11,948,400,000	<=	11,948,400,000
KRI 4	Z=	804,094	14,859	11,948,400,000	<=	11,948,400,000
KRI 5	Z=	998,494	11,952	11,933,925,000	<=	11,933,925,000
KRI 6	Z=					
KRI 7	Z=	998,494	11,966	11,948,400,000	<=	11,948,400,000
KRI 8	Z=	1,063,294	11,237	11,948,400,000	<=	11,948,400,000
KRI 9	Z=	952,653	12,485	11,893,500,000	<=	11,893,500,000
KRI 10	Z=					
KRI 11	Z=	952,653	10,444	9,949,770,000	<=	9,949,770,000
KRI 12	Z=	1,077,069	9,238	9,949,770,000	<=	9,949,770,000
KRI 13	Z=	1,077,069	9,232	9,943,980,000	<=	9,943,980,000
KRI 14	Z=					
KRI 15	Z=	1,014,861	9,793	9,938,190,000	<=	9,938,190,000
KRI 16	Z=	903,413	11,088	10,017,485,000	<=	10,017,485,000
KRI 17	Z=	1,428,293	7,012	10,014,590,000	<=	10,014,590,000
KRI 18	Z=					
KRI 19	Z=	1,544,933	5,033	7,774,900,000	<=	7,774,900,000
KRI 20	Z=	1,369,973	5,675	7,774,900,000	<=	7,774,900,000
KRI 21	Z=	1,486,613	5,232	7,777,795,000	<=	7,777,795,000
KRI 22	Z=					
KRI 23	Z=	1,486,613	5,232	7,777,795,000	<=	7,777,795,000
KRI 24	Z=	1,428,293	5,441	7,772,005,000	<=	7,772,005,000
KRI 25	Z=	1,486,613	5,228	7,772,005,000	<=	7,772,005,000

Jml Biaya Ops KRI		Alokasi Anggaran
189,991,210,000	<=	189,991,210,000

Based on the modeling of decision variable, then wespecify the objective function of the problem so that the coverage area is obtained.

Objective Function	Z max =	21,876,015	Nm2

So that the total achievements of the area from KRI that carries out of operations is as much as possible 21.876.015 NM^2.

CONSTRAIN

Assignment costs do not exceed budget allocations.

Table 8. Liquid Logistics Cost Data of KRI

No	SHIP / KRI	Endurance (day)	FO needs (Ltr/hr)	FO/E (Ltr)	Fuel costs/E (Rp)	FW needs/E (Ton Ltr)	FW costs/E (Rp)	LO needs/E (Ltr)	LO costs/E (Rp)	total costs / E (Rp)	The Total costs of a year of Operation
1	KRI Untung Suropati	4	17,600	70,400	774,400,000	25	1,250,000	150	5,250,000	780,900,000	35,140,500,000
2	KRI Nuku	4	17,600	70,400	774,400,000	20	1,000,000	150	5,250,000	780,650,000	35,129,250,000
3	KRI Lambung Mangku	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
4	KRI Hasan Basri	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
5	KRI Mandau	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
6	KRI Rencong	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
7	KRI Badik	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
8	KRI Keris	4	17,600	70,400	774,400,000	40	2,000,000	120	4,200,000	780,600,000	35,127,000,000
9	KRI Pandrong	5	17,600	88,000	968,000,000	40	2,000,000	120	4,200,000	974,200,000	35,071,200,000
10	KRI Sura	5	17,600	88,000	968,000,000	40	2,000,000	120	4,200,000	974,200,000	35,071,200,000
11	KRI Hiu	5	14,700	73,500	808,500,000	45	2,250,000	130	4,550,000	815,300,000	29,350,800,000
12	KRI Layang	5	14,700	73,500	808,500,000	45	2,250,000	130	4,550,000	815,300,000	29,350,800,000
13	KRI Kakap	5	14,700	73,500	808,500,000	45	2,250,000	130	4,550,000	815,300,000	29,350,800,000
14	KRI Kerapu	5	14,700	73,500	808,500,000	45	2,250,000	130	4,550,000	815,300,000	29,350,800,000
15	KRI Tongkol	5	14,700	73,500	808,500,000	45	2,250,000	130	4,550,000	815,300,000	29,350,800,000
16	KRI Sempari	3	14,700	44,100	485,100,000	45	2,250,000	130	4,550,000	491,900,000	29,514,000,000
17	KRI Tombak	3	14,700	44,100	485,100,000	45	2,250,000	130	4,550,000	491,900,000	29,514,000,000
18	KRI Terapang	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
19	KRI Badau	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
20	KRI Pari	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
21	KRI Sidat	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
22	KRI Tedung Naga	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
23	KRI Patola	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
24	KRI Taliwangsa	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000
25	KRI Welang	3	11,500	34,500	379,500,000	15	750,000	110	3,850,000	384,100,000	23,046,000,000

Based on the above table, it is found that the ship's endurance capability and total needs as well as liquid logistics costs in carrying out marine security operation for one year.

Table 9. Total Logistics Costs For KRI Personnel

No	SHIP KRI	Endurance (Day)	Number of Personel	TNL (Rp)	TL (Rp)	UMO (Rp)	TP (Rp)	Harkap Ops (Rp)	The Total cost of a year of operation
1	KRI Untung Suropati	4	50	11,250,000	45,000,000	378,000,000	33,750,000	112,500,000	580,500,000
2	KRI Nuku	4	45	10,125,000	40,500,000	340,200,000	33,750,000	112,500,000	537,075,000
3	KRI Lambung Mangkurat	4	70	15,750,000	63,000,000	529,200,000	33,750,000	76,500,000	718,200,000
4	KRI Hasan Basri	4	70	15,750,000	63,000,000	529,200,000	33,750,000	76,500,000	718,200,000
5	KRI Mandau	4	65	14,625,000	58,500,000	491,400,000	33,750,000	76,500,000	674,775,000
6	KRI Rencong	4	65	14,625,000	58,500,000	491,400,000	33,750,000	76,500,000	674,775,000
7	KRI Badik	4	70	15,750,000	63,000,000	529,200,000	33,750,000	76,500,000	718,200,000
8	KRI Keris	4	70	15,750,000	63,000,000	529,200,000	33,750,000	76,500,000	718,200,000
9	KRI Pandrong	5	60	13,500,000	54,000,000	453,600,000	27,000,000	61,200,000	609,300,000
10	KRI Sura	5	60	13,500,000	54,000,000	453,600,000	27,000,000	61,200,000	609,300,000
11	KRI Hiu	5	46	10,350,000	41,400,000	347,760,000	27,000,000	72,000,000	498,510,000
12	KRI Layang	5	46	10,350,000	41,400,000	347,760,000	27,000,000	72,000,000	498,510,000
13	KRI Kakap	5	44	9,900,000	39,600,000	332,640,000	27,000,000	72,000,000	481,140,000
14	KRI Kerapu	5	44	9,900,000	39,600,000	332,640,000	27,000,000	72,000,000	481,140,000
15	KRI Tongkol	5	42	9,450,000	37,800,000	317,520,000	27,000,000	72,000,000	463,770,000
16	KRI Sempari	3	43	9,675,000	38,700,000	325,080,000	45,000,000	120,000,000	538,455,000
17	KRI Tombak	3	42	9,450,000	37,800,000	317,520,000	45,000,000	120,000,000	529,770,000
18	KRI Terapang	3	21	4,725,000	18,900,000	158,760,000	45,000,000	60,000,000	287,385,000
19	KRI Badau	3	20	4,500,000	18,000,000	151,200,000	45,000,000	60,000,000	278,700,000
20	KRI Pari	3	20	4,500,000	18,000,000	151,200,000	45,000,000	60,000,000	278,700,000
21	KRI Sidat	3	21	4,725,000	18,900,000	158,760,000	45,000,000	60,000,000	287,385,000
22	KRI Tedung Naga	3	21	4,725,000	18,900,000	158,760,000	45,000,000	60,000,000	287,385,000
23	KRI Patola	3	21	4,725,000	18,900,000	158,760,000	45,000,000	60,000,000	287,385,000
24	KRI Taliwangsa	3	19	4,275,000	17,100,000	143,640,000	45,000,000	60,000,000	270,015,000
25	KRI Welang	3	19	4,275,000	17,100,000	143,640,000	45,000,000	60,000,000	270,015,000

Based on the above table, the total personnel logistics is obtained so that based on the two tables of calculation for one year, the total requirement can be calculated to carry out maritime security operations in the coalition. So that the total cost for one year from calculation is the total logistics cost table for the vessels operating for Koarmatim sea security.

Table 10. Total Logistics Costs For KRI

No	SHIP	CLASS	LIQUID LOGISTICS Rp	PERSONNEL LOGISTICS Rp	THE TOTAL COST OF A YEAR OF OPERATION
1	KRI Untung Suropati	PARCHIM	35,140,500,000	580,500,000	35,721,000,000
2	KRI Nuku	PARCHIM	35,129,250,000	537,075,000	35,666,325,000
3	KRI Lambung Mangkurat	PARCHIM	35,127,000,000	718,200,000	35,845,200,000
4	KRI Hasan Basri	PARCHIM	35,127,000,000	718,200,000	35,845,200,000
5	KRI Mandau	PSK	35,127,000,000	674,775,000	35,801,775,000
6	KRI Rencong	PSK	35,127,000,000	674,775,000	35,801,775,000
7	KRI Badik	PSK	35,127,000,000	718,200,000	35,845,200,000
8	KRI Keris	PSK	35,127,000,000	718,200,000	35,845,200,000
9	KRI Pandrong	PSK	35,071,200,000	609,300,000	35,680,500,000
10	KRI Sura	FPB	35,071,200,000	609,300,000	35,680,500,000
11	KRI Hiu	FPB	29,350,800,000	498,510,000	29,849,310,000
12	KRI Layang	FPB	29,350,800,000	498,510,000	29,849,310,000
13	KRI Kakap	FPB	29,350,800,000	481,140,000	29,831,940,000
14	KRI Kerapu	FPB	29,350,800,000	481,140,000	29,831,940,000
15	KRI Tongkol	FPB	29,350,800,000	463,770,000	29,814,570,000
16	KRI Sempari	FPB	29,514,000,000	538,455,000	30,052,455,000
17	KRI Tombak	FPB	29,514,000,000	529,770,000	30,043,770,000
18	KRI Terapang	PC	23,046,000,000	287,385,000	23,333,385,000
19	KRI Badau	PC	23,046,000,000	278,700,000	23,324,700,000
20	KRI Pari	PC	23,046,000,000	278,700,000	23,324,700,000
21	KRI Sidat	PC	23,046,000,000	287,385,000	23,333,385,000
22	KRI Tedung Naga	PC	23,046,000,000	287,385,000	23,333,385,000
23	KRI Patola	PC	23,046,000,000	287,385,000	23,333,385,000
24	KRI Taliwangsa	PC	23,046,000,000	270,015,000	23,316,015,000
25	KRI Welang	PC	23,046,000,000	270,015,000	23,316,015,000

Based on the above table, the total costs for the logistics needs of ships to secure the region can be minimized to reduce costs and budget. And also obtained a total cost when carrying out maintenance or docking.

Table 11. Total Logistics Costs For Operation

		Coverage Area Achievements (nM2)	Cost index Rp./Nm2	Operation Cost Achievements	Condition	Cost Total TW I Ops. (Rp.)
FASHARKAN 1	Z=					-
FASHARKAN 2	Z=	998,494	11,907	11,888,775,000	<=	11,888,775,000
FASHARKAN 3	Z=	868,894	13,751	11,948,400,000	<=	11,948,400,000
FASHARKAN 4	Z=	804,094	14,859	11,948,400,000	<=	11,948,400,000
FASHARKAN 5	Z=					-
FASHARKAN 6	Z=	1,063,294	11,224	11,933,925,000	<=	11,933,925,000
FASHARKAN 7	Z=	998,494	11,966	11,948,400,000	<=	11,948,400,000
FASHARKAN 8	Z=	1,063,294	11,237	11,948,400,000	<=	11,948,400,000
FASHARKAN 9	Z=					-

Total cost operation of KRI		Budget allocation
71,616,300,000	<=	71,616,300,000

Based on the above table, the total cost of operation for KRI for 3 month is 71.616.300.000 and must not exceed the allocation of funds of 71.616.300.000. So that the use of the budget can be used optimally because it does not exceed the total use. The next step is to create a scheduling model using calculation every 3 months so that it can cause problems, in this case the KRI assignment problem. And the calculation is obtained 1 objective function.

DISCUSSION

The purpose of this BIP method is to maximize coverage area coverage, so that the KRI's assignment is to secure marine security. Schedule maintenance/ docking according to the schedule and the assignment cost does not exceed the budget allocated.

This model solution produces an assignment table with zero one numbers (0-1). Xij 1 means that the i KRI is assigned an operation to sector j and Xij 0 means that the i KRI is not assigned to the j sector operation. With the help of software solver, the result of the KRI assignment to the sector as follows.

a. For the first 3 months (TW 1)

Table 12. Zero One Matrix Assignment To Tw 1

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0
6	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1
9	0	0	0	0	0	0	0	0	0
10	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1
13	0	0	0	0	0	0	0	0	0
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	0	0	0	0	0	0	0	0	0
18	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1
21	0	0	0	0	0	0	0	0	0
22	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1
25	0	0	0	0	0	0	0	0	0

= KRI

= KRI carries out maintenance/ docking

1 = means that the i KRI is assigned an operation to sector j

0 = means that the i KRI is not assigned to the j sector operation

b. For the first 3 months (TW 2)

Table 13. Zero One Matrix Assignment To Tw 2

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1
6	0	0	0	0	0	0	0	0	0
7	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1
10	0	0	0	0	0	0	0	0	0
11	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1
14	0	0	0	0	0	0	0	0	0
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1
18	0	0	0	0	0	0	0	0	0
19	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1
22	0	0	0	0	0	0	0	0	0
23	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1

= KRI

= KRI carries out maintenance/ docking

1 = means that the i KRI is assigned an operation to sector j

0 = means that the i KRI is not assigned to the j sector operation

c. For the first 3 months (TW 3)

Table 14. Zero One Matrix Assignment To Tw 3

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1
3	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1
7	0	0	0	0	0	0	0	0	0
8	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1
11	0	0	0	0	0	0	0	0	0
12	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	0	0	0	0	0	0	0	0	0
16	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1
19	0	0	0	0	0	0	0	0	0
20	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1
23	0	0	0	0	0	0	0	0	0
24	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1

= KRI

= KRI carries out maintenance/ docking

1 = means that the i KRI is assigned an operation to sector j

0 = means that the i KRI is not assigned to the j sector operation

d. For the first 3 months (TW 4)

Table 15. Zero One Matrix Assignment To Tw 4

KRI	OPERATION SECTOR								
	S-V	S-VI	S-VII	S-VIII	S-IX	S-X	S-XI	S-XIII	X-IV
1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1
8	0	0	0	0	0	0	0	0	0
9	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1
12	0	0	0	0	0	0	0	0	0
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	0	0	0	0	0	0	0	0	0
17	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1
20	0	0	0	0	0	0	0	0	0
21	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1
24	0	0	0	0	0	0	0	0	0
25	1	1	1	1	1	1	1	1	1

= KRI

= KRI carries out maintenance/ docking

1 = means that the i KRI is assigned an operation to sector j

0 = means that the i KRI is not assigned to the j sector operation

The overall results of the optimization of the assignment of Indonesian Navy are shown in the following tables.

Table 16 . Assignment Schedule Optimization Results

No	KRI	CODE	CLASS	TW 1 SECTOR	TW 2 SECTOR	TW 3 SECTOR	TW 4 SECTOR
1	**KRI Untung Suropati**	USP	PARCHIM	DOCKING	2	3	9
2	**KRI Nuku**	NUK	PARCHIM	1	DOCKING	3	9
3	**KRI Lambung Mangkur**	LAM	PARCHIM	1	2	DOCKING	8
4	**KRI Hasan Basri**	HBS	PARCHIM	2	3	4	DOCKING
5	**KRI Mandau**	MDU	PSK	DOCKING	3	4	8
6	**KRI Rencong**	RCG	PSK	2	DOCKING	5	7
7	**KRI Badik**	BDK	PSK	3	4	DOCKING	7
8	**KRI Keris**	KRS	PSK	3	4	5	DOCKING
9	**KRI Pandrong**	PDG	FPB	DOCKING	5	6	6
10	**KRI Sura**	SRA	FPB	4	DOCKING	6	6
11	**KRI Hiu**	HIU	FPB	4	5	DOCKING	5
12	**KRI Layang**	LYG	FPB	5	6	7	DOCKING
13	**KRI Kakap**	KKP	FPB	DOCKING	6	7	5
14	**KRI Kerapu**	KRP	FPB	5	DOCKING	8	4
15	**KRI Tongkol**	TKL	FPB	6	7	DOCKING	4
16	**KRI Sempari**	SPR	PC	6	7	8	DOCKING
17	**KRI Tombak**	TOK	PC	DOCKING	8	9	3
18	**KRI Terapang**	TRP	PC	7	DOCKING	9	3
19	**KRI Badau**	BDU	PC	7	8	DOCKING	2
20	**KRI Pari**	PRI	PC	8	9	1	DOCKING
21	**KRI Sidat**	SDT	PC	DOCKING	9	1	2
22	**KRI Tedung Naga**	TDN	PC	8	DOCKING	2	1
23	**KRI Patola**	PTL	PC	9	1	DOCKING	1
24	**KRI Taliwangsa**	TWS	PC	9	1	2	DOCKING
25	**KRI Welang**	WLG	PC	DOCKING	4	3	2

Table 16. Total Results Optimization Of Coverage Area

NO	SECTOR	TW 1	TW 2	TW 3	TW 4
		SHIP ASSIGNMENT	SHIP ASSIGNMENT	SHIP ASSIGNMENT	SHIP ASSIGNMENT
1	SECTOR I	KRI 2, KRI 3	KRI 23, KRI 24	KRI 20, KRI 21	KRI 22, KRI 23
2	SECTOR II	KRI 4, KRI 6	KRI 1, KRI 3	KRI 22, KRI 24	KRI 19, KRI 21, KRI 25
3	SECTOR III	KRI 7, KRI 8	KRI 4, KRI 5	KRI 25, KRI 1, KRI 2	KRI 17, KRI 18
4	SECTOR IV	KRI 10, KRI 11	KRI 7, KRI 8, KRI 25	KRI 4, KRI 5	KRI 14, KRI 15
5	SECTOR V	KRI 12, KRI 14	KRI 9, KRI 11	KRI 6, KRI 8	KRI 11, KRI 13
6	SECTOR VI	KRI 15, KRI 16	KRI 12, KRI 13	KRI 9, KRI 10	KRI 9, KRI 10
7	SECTOR VII	KRI 18, KRI 19	KRI 15, KRI 16	KRI 12, KRI 13	KRI 6, KRI 7
8	SECTOR VIII	KRI 20, KRI 22	KRI 17, KRI 19	KRI 14, KRI 16	KRI 3, KRI 5
9	SECTOR IX	KRI 23, KRI 24	KRI 20, KRI 21	KRI 17,KRI 18	KRI 1, KRI 2
COVERAGE AREA MAX (NM2)		21.626.251	24.331.189	22.219.439	25.474.355
				TOTAL COVERAGE AREA	= 93.651.234

Total maximum coverage area for a year that can be secure by KRI in all sectors is 93,651,234 NM^2 (The total area of all sector 1-9 is 1,230,442 NM^2). Security level of the operating sector (Area of coverage area that is secured divided by total operating sector). Security level area 93,651,234 NM^2/ 1,230,442 NM^2 = 76,11.

The higher of area security level obtained from the KRI assignment, it means that the higher of coverage area that is secured in the operation of the presence at sea by the ship with the composition of the KRI assignment above.

4. CONCLUSION.

The result of the optimization were the composition of the assignment of 25 KRI to the 9 operational sector of maritime security Koarmatim. The maximum coverage area reached is 93,651,234 NM^2, with an area safeguard level of 76,11 from the entire area of operating sector I to IX (1,230,442 NM^2). And the benefits that can be obtained after optimization is the increase in the secured coverage area in the operating sector amounting to TW 1: 20%, TW 2: 29%, TW 3: 23 %, and TW 4: 32%, or an increase in coverage area up to 26% during the year of operation and assignment before optimization 68,901,373 NM^2 to 93,651,234 NM^2 after optimization).

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